The association between self-reported physical activity levels and patterns and BMI of urban South African young adult women

Maxine Bernadette van Greenen

0405973Y

Department of Paediatrics, School of Clinical Sciences, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in the Branch of Paediatrics

Johannesburg, 2020

DECLARATION

I Maxine Bernadette van Greenen declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the Branch of Paediatrics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of Candidate)

19 day of November 2020

ABSTRACT

Background: Overweight and obesity are prevalent amongst urban South African women. Increasing levels of physical inactivity in these women are contributing to this pandemic, and these women are therefore at higher risk of developing non-communicable diseases. The aim of this study was to assess the self-reported physical activity levels and patterns of young adult urban South African women and determine if physical activity levels and patterns were associated with overweight and obesity.

Methods: The Global Physical Activity Questionnaire was used to collect self-reported physical activity data in a cross-sectional study of 511 black females between 21-23 years of age from the Birth to Twenty plus cohort in Soweto, Johannesburg. Body mass index (BMI) was determined using standardised height and weight measurements. Participants who accumulated sufficient weekly physical activity according to the World Health Organisation (WHO) minimum recommended guidelines for physical activity were classified as WHO active and participants who did not meet these criteria were classified as WHO inactive.

Results: The combined prevalence of overweight and obesity was 46.5% despite most (76.9%) of the women complying with the WHO minimum recommended guidelines for weekly physical activity. Walking for travel contributed most (33%) to weekly moderate-vigorous physical activity (MVPA), and less than a quarter (22%; n=109) of the participants reported any leisure time physical activity. The median sitting time was 6 hours a day and sitting time was not significantly different between the activity groups (WHO Active 360(260-480) min/day vs WHO Inactive 360(240-540) min/day; p=0.781)). We found no association between physical activity or sitting time, and BMI.

Conclusion: This study shows that the majority of this group of young urban black females are classified as physically active according to the WHO minimum recommended guidelines for weekly physical activity, yet a large proportion are overweight and obese.

ACKNOWLEDGEMENTS

I would like to thank the following people for their continued support, encouragement, enthusiasm, and inspiration.

- My family
- My supervisors, Dr Alessandra Prioreschi and Prof. Lisa Micklesfield

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

WHO	World Health Organization
STEPS	The WHO StepWise
BMI	Body Mass Index
SADHS	South African Demographic and Health Survey
BT20	Birth to Twenty
BT20+	Birth to Twenty plus
NCDs	Non-communicable diseases
GPAQ	Global Physical Activity Questionnaire
MVPA	Moderate-Vigorous-Physical activity
USA	United States of America
SD	Standard Deviations
IQR	Interquartile range

PUBLICATION SUBMISSIBLE FORMATTED RESEARCH REPORT

The association between self-reported physical activity levels and patterns and BMI of urban South African young adult women

Maxine B. van Greenen, *Alessandra Prioreschi, *Lisa K. Micklesfield

Department of Paediatrics, School of Clinical Sciences, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

***Corresponding Authors**

Dr Alessandra Prioreschi

Prof. Lisa Micklesfield

ABSTRACT

Background: Overweight and obesity are prevalent amongst urban South African women. Increasing levels of physical inactivity in these women are contributing to this pandemic, and these women are therefore at higher risk of developing non-communicable diseases. The aim of this study was to assess the self-reported physical activity levels and patterns of young adult urban South African women and determine if physical activity levels and patterns were associated with overweight and obesity. **Methods:** The Global Physical Activity Questionnaire was used to collect self-reported physical activity data in a cross-sectional study of 511 black females between 21-23 years of age from the Birth to Twenty plus cohort in Soweto, Johannesburg. Body mass index (BMI) was determined using standardised height and weight measurements. Participants who accumulated sufficient weekly physical activity according to the World Health Organisation (WHO) minimum recommended guidelines for physical activity were classified as WHO active and participants who did not meet these criteria were classified as WHO inactive. **Results:** The combined prevalence of overweight and obesity was 46.5% despite most (76.9%) of the women complying with the WHO minimum recommended guidelines for weekly physical activity. Walking for travel contributed most (33%) to weekly moderate-vigorous physical activity (MVPA), and less than a quarter (22%; n=109) of the participants reported any leisure time physical activity. The median sitting time was 6 hours a day and sitting time was not significantly different between the activity groups (WHO Active 360(260-480) min/day vs WHO Inactive 360(240-540) min/day; p=0.781)). We found no association between physical activity or sitting time, and BMI. **Conclusion:** This study shows that the majority of this group of young urban black females are classified as physically active according to the WHO minimum recommended guidelines for weekly physical activity, yet a large proportion are overweight and obese.

Key Words: Physical activity, BMI, Sitting time, Women, Urban

Introduction

There is extensive evidence that insufficient physical activity, overweight and obesity are major contributors to non-communicable diseases (NCDs) resulting in death and disability worldwide[1-3]. The morbidity and mortality from NCDs, which include heart disease, stroke, diabetes, chronic respiratory diseases, breast and colon cancer, are increasing, and the World Health Organisation (WHO) estimates that by 2030 NCDs will be the leading cause of death in low and middle income countries [2]. The National Burden of Disease Study for South Africa reported that between 1997 and 2010, 39% of the total deaths in South Africa were due to NCDs and 36% of these deaths occurred before the age of 60 years[1]. Independent of overweight and obesity, physical inactivity has been identified as the fourth leading risk factor for global mortality as well as a modifiable risk factor for NCDs [3]. A physically active lifestyle is considered to be central in the fight against NCDs. The health benefits of physical activity include a lower risk of all-cause mortality, coronary heart disease, high blood pressure, stroke, metabolic syndrome, Type 2 diabetes, breast cancer, colon cancer, depression, and strong evidence of higher levels of cardiorespiratory and muscle fitness, healthier body weight and composition, enhanced bone health, higher level of functional health and better cognitive function resulting in positive effects on depression, anxiety and stress relief [3]. The pathophysiology of how physical activity impacts NCDs is discussed in a systemic review by Anderson et al.; that included studies from high, middle and low income countries, including adults and children [4]. Some of the pathophysiological pathways discussed were:

- Physical activity improves myocardial strength and oxygen delivery, while decreasing myocardial oxygen demand resulting in improved myocardial function and lower systolic blood pressure. Physical activity increases HDL-cholesterol and decreases inflammation thereby lowering the risk of developing heart disease.

- Physical activity improves insulin sensitivity and enhances glucose uptake into cells.
- Physical activity enhances bone health by increasing bone mineral density, improving muscle strength and functional capacity, preventing osteoporosis, and decreasing the risk of falls and fractures.
- Physical activity may delay the onset of dementia, Alzheimer's dementia and Parkinson's Disease by inducing molecular adaptations in multiple brain regions, thus improving functional and structural neural properties [4].

Sedentary behaviour has become a new area of public health concern due to increasing epidemiological research that shows a significant relationship between time spent in sedentary behaviour and all-cause mortality, cardiovascular mortality, cardiovascular disease incidence and type-2 diabetes incidence [5]. The 2010 WHO Global Recommendations on Physical Activity for Health briefly discusses the risks associated with a sedentary lifestyle but there are no specific recommendations regarding sedentary behaviour, due to insufficient evidence at the time of publishing [3]. The 2020 Draft WHO Guidelines on physical activity and sedentary behaviour for children and adolescents, adults and older adults will include new recommendations for adults, and guidelines for sub-populations such as pregnant and postpartum women, and those living with chronic illness and disability. The sedentary behaviour recommendation for adults 18+ years is broad: "*Adults should limit the amount of time spent being sedentary and replacing sedentary time with physical activity of any intensity (including light intensity) has health benefits; Adults who are highly sedentary should aim to achieve or exceed the upper levels of recommended moderate-to-vigorous intensity physical activity* " [6]. The draft guidelines also provide updated evidence on the amount (frequency, intensity, duration) of physical activity that will offer health benefits and alleviate health risks [6].

The prevalence of overweight and obesity in South Africa is increasing [7]; and self-reported physical activity data from 2003 shows that only 18% of young women (15-24 years) were classified as sufficiently active [8]. A review by Micklesfield et al. showed that urbanised South Africans are adopting a more Westernised lifestyle, which includes consuming a diet higher in energy, sugar, and fat; as well as insufficient physical activity and high sedentary behaviour [9]. For females, overweight and obesity starts at a young age and increases with age. Studies have consistently found that overweight and obesity in childhood and adolescence tracks into adulthood, implying that that these risk factors for NCDs have significant implications for the burden of disease in adulthood [10-12]. This trajectory was observed by Lundeen et al., who examined sex differences in obesity incidence from early childhood to late adolescence in the Bt20 cohort [12]. They showed that girls who were overweight and obese in the first 8 years of life, had increased odds of being obese at 16–18 years. For example, overweight and obese girls at age 1-2 years, had 3.6 and 8.0 ($P < 0.001$) odds ratio of being obese at 16-18 years respectively; and for overweight and obese girls aged 4-8 years, the odds ratio was 6.8 and 42.3 ($P < 0.001$) respectively [12]. Furthermore, Hanson et al. found that when examining longitudinal patterns of physical activity and sedentary behaviour in urban dwelling South African adolescents (12-18 years); all of the adolescent females in the study did not meet the recommendations for moderate vigorous physical activity (MVPA) (assessed as organised sport) and reported sitting times of more than 2 hours/day, throughout adolescence [13].

Research has shown that the risk factors for NCDs; physical inactivity, overweight and obesity are prevalent in the South African population. The tracking of overweight and obesity from childhood and adolescence into adulthood, and the reported low physical activity levels of black South African adolescent females implies that young adult urban black females are at high risk for morbidity and mortality associated with overweight, obesity and physical inactivity. Thus, the aim of this study was to assess the self-reported physical activity levels and patterns of young adult urban South African women, and to determine if physical activity levels and patterns were associated with overweight and obesity, as measured by BMI. We hypothesize that if young adult urban South African women achieved the recommended minimum WHO guidelines for physical activity for health they would have a lower BMI and be less likely to be overweight or obese.

Methodology

Study design and participants

This cross-sectional study included 511 black female participants between the ages of 21-23 years from the Birth to Twenty plus cohort (BT20+) [14]. BT20+ began in 1990 and is Africa's largest and longest running longitudinal study of child and adolescent health and development. This birth cohort study enrolled 3273 singleton infants born between April 23 - June 6 1990 to women residing in Soweto who fulfilled the study inclusion criteria [14]. At the time of recruitment, the participants included all South African race groups and was representative of the demographics of Soweto. Most of the cohort were Black African 78%, other race groups i.e. Coloured 12%, White 6% and Indian 4% comprised the remainder of the cohort. The representation of females and males was approximately even: 51% and 49% respectively. Initially, data were collected during a 7-week enrolment period, from pregnant women attending public antenatal clinics who were predicted to deliver during the 7 weeks. The 511 black female participants between the age range 21-23 years included in the present study were the urban component of a larger study – The Birth to Twenty (BT20) Young Adult survey. This age range was pre-determined and set as an assessment time point by the BT20+ study. The aim of the BT20 Young Adult survey was to compare health outcomes and health behaviours between rural and urban young adult South African women [15-21].

Participants from the current sample were excluded from this study if they were or had ever been pregnant (n=18) or had incomplete Global Physical Activity Questionnaire

(GPAQ) data and anthropometric assessments (n=4). This resulted in a final study sample of n=489.

Anthropometric measurements and BMI

The anthropometric measurements included weight and height. Weight was measured to the nearest 0.1kg using a standard electronic scale (Tanita model TBF-410; Arlinghton Heights, IL, USA). Height was measured to the nearest millimetre (mm) using a stadiometer (Holtain, Crymych, UK). During the measurements, the participants wore light clothes and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters and categorised according to WHO categories [22] as follows:

• BMI <18.5 kg/m^2, underweight range

• BMI 18.5 to 24.9 kg/m^2, normal or healthy weight range.

• BMI 25.0 to 29.9 kg/m^2, overweight range.

• BMI ≥ 30.0 kg/m^2, obese range

Physical Activity

Self-reported physical activity was obtained using the Global Physical Activity Questionnaire (GPAQ). The GPAQ was developed as part of The WHO StepWise approach to chronic disease risk factor surveillance (STEPS) to assess physical activity, especially in low- and middle-income countries. The advantage of the GPAQ is that it captures physical activity performed in the different domains, namely: work, travel, and leisure time. This is an important consideration when assessing physical activity in developing countries because research suggests that occupational, domestic and travel related activities may contribute more to overall energy expenditure than leisure time or recreational activity in these settings [23,24]. In 2009 the GPAQ was validated internationally [24]. In South Africa, GPAQ has been used successfully to collect data on physical activity in different population groups of varying ages [25-28]. The questionnaire was completed in the form of face to face interviews, conducted by trained field workers. The GPAQ questionnaire is comprised of 16 questions. The questions are grouped into different physical activity domains: activity at work, travel, and leisure activity. Work and leisure activity are each further divided into two sub-domains defined by the intensity of the activity: vigorous and moderate. Travel is assessed as any form of active commuting such as walking or cycling to and from places for work, shopping, or church. Travel is scored as moderate intensity physical activity according to the GPAQ analysis guide. The duration of physical activity is recorded as minutes/week. If a participant reported no physical activity in a specific domain, this was recorded as zero [29]. The GPAQ assesses sedentary behaviour through a single question regarding how much time is spent sitting in a day. Therefore sitting time (minutes/day) was used as a proxy for sedentary behaviour [29]. Total moderate-vigorous intensity physical activity (MVPA) was calculated by adding work vigorous and moderate intensity physical activity, leisure vigorous and moderate intensity physical activity, and travel related moderate intensity physical activity [29].

Participants were categorised as physically active or physically inactive according to the WHO criteria outlined in the document, The Global Recommendations on Physical Activity for Health [3]. WHO guideline defines active as taking part in moderate intensity physical activity for at least 150 minutes throughout the week, or at least 75 minutes of vigorous intensity physical activity throughout the week, or a combination of moderate-vigorous intensity physical activity (MVPA) of at least 150 minutes a week. Participants who did not meet these criteria for physical activity were classified as WHO inactive [29].

Data Analysis

Data was captured into an MS Excel (Microsoft, USA) spreadsheet. Raw physical activity data were categorised into domains using the GPAQ analysis guide [29]. The final data set was exported into the statistical software program STATA for analysis. For descriptive analysis, means and standard deviations (SD) were reported for continuous variables (age and BMI), and percentages were used to describe categorical variables (BMI categories). The Shapiro Wilk test was used to test for normality of distribution. Continuous variables that were not normally distributed (time spent in the different physical activity domains) were reported as medians and interquartile range (IQR). The physical activity data displayed many zeros (participants who reported no physical activity), particularly for the vigorous intensity physical activity and leisure MVPA domains. To determine summary statistics for these domains, a second analysis was done where participants who reported zero vigorous intensity activity and leisure MVPA were excluded from the descriptive analysis. A Kruskal-Wallis H test was used to determine if time spent in the different PA domains was significantly different between the four BMI categories. The Wilcoxon rank-sum (Mann-Whitney U) test was used to determine if there was a difference in the continuous BMI data between active and inactive groups. Pearson's Chi^2 test was used to determine differences between categorical BMI classification for active and inactive groups. A univariate analysis was done to determine if any of the physical activity domains were associated with BMI, and since there were no associations, we did not do a regression analysis. A p-value of $p<0.05$ was considered significant.

Results

The final sample consisted of 489 urban black females with a mean age of 22.8±0.5 years. The study sample had a mean BMI of 25.3±5.9 kg/m^2. Overall, 46.4% (n=227) of the participants had a normal BMI and 7.2% (n=35) were underweight. The prevalence of overweight and obesity in the sample was 29.5% (n=144) and 17% (n=83), respectively.

Physical Activity

Table 1 summarises the medians and interquartile ranges of the self-reported time spent in physical activity domains (min\wk) and sitting time (min/day) stratified by WHO Active and WHO Inactive. This self-reported physical activity data was not normally distributed and heavily skewed towards zero as shown by the summary statistics (Table 1). The total weekly median MVPA of this group of urban women was 420(160-900) min/wk. Most (76.9%, n=376) of the women complied with the WHO minimum recommended guidelines for weekly physical activity. Not shown in Table 1 are the percentage contributions to total weekly MVPA from each physical activity domain; work 59%, travel 32% and leisure 9% respectively. Secondary analysis summary statistics for the two domains with participants who reported zero vigorous intensity activity and leisure MVPA excluded are shown in italics (Table 1). Only 52 (11%) out of the 489 participants reported any vigorous physical activity, 85% of the vigorous activity was accumulated during leisure activity with 15% of the vigorous activity accumulated during work activity. Overall, less than a quarter (22%, n=109) of the participants reported any leisure MVPA. The median sitting time was 6 hours a day (360 (240-480) min/day). Sitting time was not significantly different ($p=0.781$) between the activity groups; (WHO Active 360(260-480) min/day vs WHO Inactive 360(240-540) min/day) (Table1).

Figure 1 illustrates the distribution of time spent in physical activity for each domain and illustrates the variability in the data observations. Total MVPA, moderate physical activity and total travel activity had a greater distribution around the lower end of time spent in these activities, between 0-100 min/wk. There was a greater distribution of time spent in work and leisure time MVPA. All domains of physical activity were significantly higher in the WHO Active group compared to the WHO Inactive group ($p<0.001$).

Physical Activity and BMI

In this study population, there were no significant differences in the time spent in the different physical activity domains, or sitting time, between the BMI categories (Table 2), and the distribution of weekly MVPA (min/wk) was similar between the BMI categories (Figure 2). Spearman’s correlation coefficients showed no relationship between any of the physical activity domains and BMI, while Figure 3 illustrates that there actually is not much difference in the patterns of physical activity between the BMI groups. There was also no significant difference in continuous BMI between the WHO Active (25.4 ± 6.15 kg/m^2) and Inactive (25.0 ± 5.07 kg/m^2) groups (Z=0.28 p=0.51). When comparing BMI categories between the WHO Active and Inactive groups, the results where similar (X^2=3.596 p=0.31), showing no significant difference (Table 3).

Figure 4 represents the median sitting time (min/day) for each BMI category across the Active and Inactive groups. There were no significant differences in sitting time according to BMI ($X^2(2)$ =0.38, p=0.94), and the median sitting times between the activity groups were not different.

Simple univariate analysis revealed that time spent in the different physical activity domains was not significantly associated with BMI.

Discussion

The aim of this study was to describe the self-reported physical activity levels and patterns in a small sample (n=489) of South African young adult women from Soweto. We have shown a 46.5% prevalence of overweight and obesity, and that 76.9% are physically active according to the WHO minimum Global Recommendations for Physical Activity for Health. Despite the high prevalence of physically active women, these women also exceeded recommended daily sitting times and we found no association between physical activity and BMI or sitting time and BMI.

The prevalence of women meeting physical activity guidelines in this study is comparable to other South African studies assessing the physical activity patterns of urban black South African women. Gradidge et al., reported that 67% of the women in their sample aged 33-49 years were physically active [30], and Dickie et al., reported a prevalence of 61% in women of a similar age to the women in this study [31]. Both of these studies used GPAQ. Conversely when physical activity was objectively assessed in a group of young (19-20 years) urban women Prioreschi et al., showed a much lower prevalence (20%) of women meeting the guidelines [32]. The difference in the physical activity prevalence shown by Prioreschi et al., can be explained by the different method used to assess physical activity. Accelerometer measurement of physical activity is an objective method of assessing physical activity and therefore more accurate in recording MVPA, compared to self-reported physical activity assessments such as GPAQ [33-35]. Population based surveys that examined global trends in physical activity, have shown that in low and middle income countries like South Africa, habitual activity such as travel and work related activity, contribute most to total weekly physical activity whereas leisure activity contributes the least [23,36]. In developing countries vigorous activity is more likely to be accumulated during leisure activities[23]. Our findings show that work and travel physical activities were the domains with the highest contribution (59% from work and 32% from travel) to total weekly physical activity, while leisure activity contributed only 9%. Gradidge et al., found a similar pattern of physical activity, work and travel contributed 56% and 34% respectively to overall physical activity [30]. Very few of the women in our study (11%) performed vigorous activity. Accumulating an adequate amount of vigorous activity is a challenge in developing countries like South Africa due to barriers to physical activity, especially leisure time activity such as time constraints, environmental constraints, safety and security and poor understanding of the benefits of exercise [8]. When physical activity was objectively measured in the same population at a younger age and smaller sample size, Prioreschi et al., found that light intensity physical activity contributed most (43%) to the overall weekly physical activity of the female participants, and moderate intensity physical activity contributed only 15% to the overall weekly physical activity [32]. The disparities between self-reported physical activity and objective assessment of physical activity in the same population is a common finding that can be explained by the limitations of self-reported physical activity questionnaires [34]. In this study we used the GPAQ to assess physical activity. The GPAQ has been proven to be a valuable and reliable tool for collecting physical activity data from large population group studies especially in poorly resourced low and middle income countries, however it does have limitations [23,24]. Self-reported physical activity questionnaires such as the GPAQ are prone to recall bias which results in over estimation of time spent in overall physical activity and in the various physical activity domains [37]. The GPAQ does not provide information about bouts of activity, continuous activity, and weight bearing activities [34], while objective physical activity measurements provide information on step counts and time spent in different physical activity intensities i.e. light, moderate and vigorous [34,35]. Consequently, comparing physical activity levels between studies is complex due to the differences between objective and subjective measurements of physical activity. Another recognised limitation of self-reported physical activity is that respondents do not understand how to identify the intensity of the activity. GPAQ assesses walking for travel as MVPA, however the exact intensity of habitual walking for travel is not known [38]. This inability to identify walking intensity was demonstrated in the reported results of a randomised control trial; where after a moderate-intensity demonstration walk on a treadmill, American adults (35-55years) reported significantly fewer minutes of total weekly MVPA ($P < 0.01$), however the effect of the demonstration walk at the 6 month questionnaire was not significant ($P = 0.06$) [38]. Recently, research has focused on whether walking cadence (defined as steps/minute) can be used to qualify as MVPA, because it places emphasis on the speed of steps and therefore can act as a method to estimate intensity [39,40]. In a controlled clinical research setting, moderate intensity walking is approximately a walking cadence of 100 steps/min in healthy adults aged 18-55 years [39]. However when walking cadence was tested outside of a clinical settings (“free living spaces”) the results were inconclusive; because the ability to walk at 100 steps/minute is influenced by many variables including age, gait pattern, height, leg length and BMI [40]. A walking cadence of 100 steps/min has low sensitivity and specificity for approximating moderate intensity physical activity but researchers agree that it can be used as a practical method to estimate walking intensity [39]. More research is needed in different countries and diverse populations assessing walking cadence as a proxy for MVPA before it forms part of the physical activity guidelines [39,40].

The women in this study were on average overweight with a mean BMI of 25.3 ± 5.9 kg/m^2 and we found that meeting the WHO Global Recommendations for Physical Activity for Health was not associated with BMI. We also found no significant differences in the time spent in the different physical activity domains between the BMI categories. These results correspond with other South African studies assessing self-reported physical activity , which showed that physically active urban black females had high BMI's; Gradidge et al. reported a mean BMI of 30.3 ± 6.73kg/m^2, and Dickie et al. reported a mean BMI of 28.0 ± 7.5 kg/m^2 [30,31]. In an international study of five low and middle income countries that included South Africa Dugas et al. found that young (25-45 years) adults of African descent who, despite accumulating adequate amounts of physical activity at baseline continued to gain weight over the two year study period, and the yearly weight gain was highest in the low income countries (1.54 kg/year in South Africa and 1.41 kg/year in Ghana). These South African studies including our study highlight the complexity of the association between physical activity and body weight and suggests that confounders such as changing dietary patterns and food environments are important influencing factors when investigating the relationship between physical activity and body weight. Furthermore physical activity is multidimensional, and the true association is often not evident due to measurement error, reverse causality between physical activity and body weight, and other confounding factors such as; socioeconomic status, age, sex lifestyle and behaviour.[41] The effect of confounding factors on body weight (assessed as BMI) was demonstrated in a study that included the female caregivers (44-55 years) of the Bt20+ cohort. The authors reported significant positive associations between: BMI and unmarried status, BMI and socioeconomic status (assessed as household asset score); and significant inverse association between: BMI and home language, BMI and smoking, BMI and level of education [42]. Another important factor to consider is the validity of BMI as a proxy for body composition or adiposity. BMI is a measure of excess weight, not body fat, relative to height. For a BMI of >25 kg/m^2 i.e. overweight, it is assumed that the high BMI is mainly due to fat, whereas muscle mass also contributes to BMI. In a systemic review that assessed the diagnostic performance of BMI to detect adiposity, the authors concluded that the cut off values used to diagnose obesity have a high specificity but a low sensitivity, and failed to identify half of the people with excess body fat percentage [43]. In a South African study Kruger et al., showed that the BMI cut-off point that identified cardiometabolic risk in Sotho men and women (32-52 years) was much lower (22 kg/m^2, and 28kg/m^2 respectively) than the internationally accepted WHO BMI cut off points for overweight and obesity [44]. Rush et al. showed that ethnic differences exist in the relationship between BMI, body fat percentage and waist circumference in South African women (18-60 years); black women had a lower BMI (29kg/m^2) compared to white women (30kg/m^2) at a given body fat percentage (39%), and they had less central fat mass than the white women at the same waist circumference [45].

The women in this study report being sedentary for 25% (6 hours) of their day, with no difference in sitting time between BMI categories, or active and inactive groups. In a study of similar aged South African female university students, the authors reported comparable sitting times (5.5 hours/day) and no difference in sitting times according to BMI categories [46]. However, to offset this sitting time, normal weight students reported significantly more MVPA (370 min/wk; $p<0.05$) than their overweight (190 min/wk) and obese (90 min/wk) counterparts [46]. In comparison other South African studies reported sitting times of 8.5 hours/day in urban black women (25-45 years) [47], and 3 hours /day in women aged 33-49 years [30]. When sitting time was objectively measured, Prioreschi et al., reported a high sitting time of 9.5 hours/day, in women aged 19-20 years, living in Soweto [32]. There is consensus that sitting for long periods of time has a negative effect on health and may be an independent risk factor for chronic disease and all-cause mortality [48]. It would be reasonable to conclude then, that sitting for long periods will result in obesity, a risk factor for NCDs, but there is no clear evidence to support this. In a systemic review of review articles that assessed the association between sedentary behaviours and risk of obesity in adults in developed countries, Biddle et al. found insufficient evidence to conclude that there is an association between sedentary behaviour and obesity in adults. However they did find that screen time (assessed as sitting watching television) - a specific type of sedentary behaviour - may be associated with weight gain in older adults; and for youth an increase in the risk of becoming obese in adulthood [49]. The message that a physically active lifestyle is beneficial for overall health and well-being, and that a sedentary lifestyle has adverse health effects are well described but not much is known about the volume of physical activity that is needed to attenuate the association between sedentary behaviour and increased health risks and mortality. Ekelund et al. concluded that sitting times of ≥ 4 hours/day was associated with increased risks of chronic disease and all-cause mortality in adults (≥ 45 years) from developed countries, and to reduce the all-cause mortality risk associated with sitting for ≥8 hours/day and television viewing for ≥5 hours /day, exercise levels need to be 2-3 times higher than the current recommended physical activity guidelines for health [48]. Interestingly achieving adequate amounts of MVPA was not protective against the risk of all-cause mortality associated with sitting watching television for ≥ 3hours/day. The authors note that this association is not as a result of causation between sitting watching television and an increased risk of mortality, but that sitting watching television is a specific type of sedentary behaviour associated with unhealthy behaviour such as; increased snacking on nutritionally dense foods, less inclined to exercise, watching television after eating which might affect metabolism [48]. This evidence linking prolonged periods of sitting with adverse health outcomes and all-cause mortality has prompted some countries to update their national physical activity guidelines to include ways to reduce daily sitting time, and to shift the focus of the public health message prioritising accumulating an adequate amount of MVPA.

A strength of this study is that the sample population is part of large population-based cohort. The use of GPAQ and the GPAQ analysis protocol is both a strength and a limitation. The strengths of using GPAQ are that it allows for consistency of physical activity measurement with the use of GPAQ showcards and we were able to report findings on domain specific physical activity. The limitation of using GPAQ is that the questionnaire is prone to recall bias resulting in inaccurate estimates of physical activity. Other limitations include, only including urban women in the study sample, which may limit the ability to translate these findings to other populations. We did not assess any social, demographic, cultural or environmental factors that influence physical activity and BMI. Not including these potential confounders can lead to bias in study results and erroneous conclusions.

Conclusion

This study shows that the majority of this group of young urban black females are classified as physically active, yet a large proportion are overweight and obese. The study has highlighted the growing evidence that the relationship between physical activity levels and patterns, and obesity assessed as BMI, should not be investigated in isolation. This emphasises that a “one size fits all” public health message is not sustainable in a developing country like South Africa. Perhaps the public health messages promoting a healthy lifestyle and healthy behaviours need to be strongly reinforced with the aim to improve overall health and as a result reduce the risk of both communicable diseases and NCDs.

Tables

Table1: Time spent in physical activity domains (mins/wk) stratified by WHO Active, WHO Inactive groups

PHYSICAL ACTIVITY DOMAIN	Total n= (489)	WHO Active n= (376)	WHO Inactive n= (113)	P value
Total Vigorous PA (min/wk)	0(0-0)	0(0-0)	0(0-0)	0.004
Total Vigorous PA after excluding zero activity; n=52	*459(15-2880)*	*261(135-435)*	*80(65-105)*	*0.023*
Total Moderate PA (min/wk)	360(140-840)	540(280-1020)	63(20-100)	<0.001
Total MVPA (min/wk)	420(160-900)	600(300-1063)	70(30-100)	<0.001
Total Work MVPA (min/wk)	20(0-450)	195(0-720)	0(0-0)	<0.001
Total Travel moderate PA (min/wk)	140(60-270)	200(100-300	60(0-100)	<0.001
Total Leisure MVPA (min/wk)	0(0-0)	0(0-60)	0(0-0)	<0.001
Total Leisure MVPA after excluding zero activity; n=109	*259(3-1260)*	*240(135-360)*	*80(40-120)*	*0.114*
Sitting Time (min/day)	360(240-480)	360(260-480)	360(240-540	0.782

All data are presented as Median (IQR)

Table 2: Time spent in physical activity domains (mins/wk) between BMI groups

PHYSICAL ACTIVITY DOMAIN	BMI CATEGORIES				P value
	Underweight <18.4 kg/m^2	Normal weight 18.5-24.9 kg/m^2	Overweight 25-29.9 kg/m^2	Obese >30 kg/m^2	
Total Vigorous PA (min/wk)	0(0-0)	0(0-0)	0(0-0)	0(0-0)	0.992
Total Vigorous PA after excluding zero activity; n=52	*70(60-2400)*	*240(90-360)*	*315(150-1080)*	*300(195-390)*	*0.526*
Total Moderate PA (min/wk)	200(180-840)	360(120-880)	120(365-968)	390(150-720)	0.878
Total MVPA (min/wk)	315(180-900)	420(140-900)	458(150-1050)	420(180-750)	0.697
Total Work MVPA (min/wk)	60(0-420)	0(0-420)	95(0-600)	0(60-450)	0.697
Total Travel moderate PA (min/wk)	180(100-300)	120(60-280)	150(65-257.5)	150(60-270)	0.585
Total Leisure MVPA (min/wk)	0(0-0)	0(0-0)	0(0-0)	0(0-0)	0.653
Total Leisure MVPA after excluding zero activity; n=109	*125(165-225)*	*210(90-360)*	*240(165-495)*	*270(128-390)*	*0.374*
Sitting Time (min/day)	360(300-480)	360(240-480)	360(240-480)	360(240-540)	0.946

All data are presented as Median (IQR)

Table 3: Pearson's Chi^2 between BMI Categories and the two groups WHO Active and WHO Inactive

BMI Categories	WHO Inactive (n=113)	WHO Active (n=376)	P value
Underweight (n, chi contribution, %)	5 1.2 1.0	30 0.4 6.1	0.624
Normal (n, chi contribution, %)	58 0.6 11.9	169 0.2 34.6	0.545
Overweight (n, chi contribution, %)	35 0.1 7.2	109 0.0 22.3	0.870
Obese (n, chi contribution, %)	15 0.9 3.1	68 0.3 13.9	0.564
Total (n, chi contribution, %)	113 2.8 23.1	376 0.8 76.9	
Fishers Exact **Pearson's Chi^2(3) = 3.596**		***Pr* 0.328** ***Pr* 0.309**	

Figures

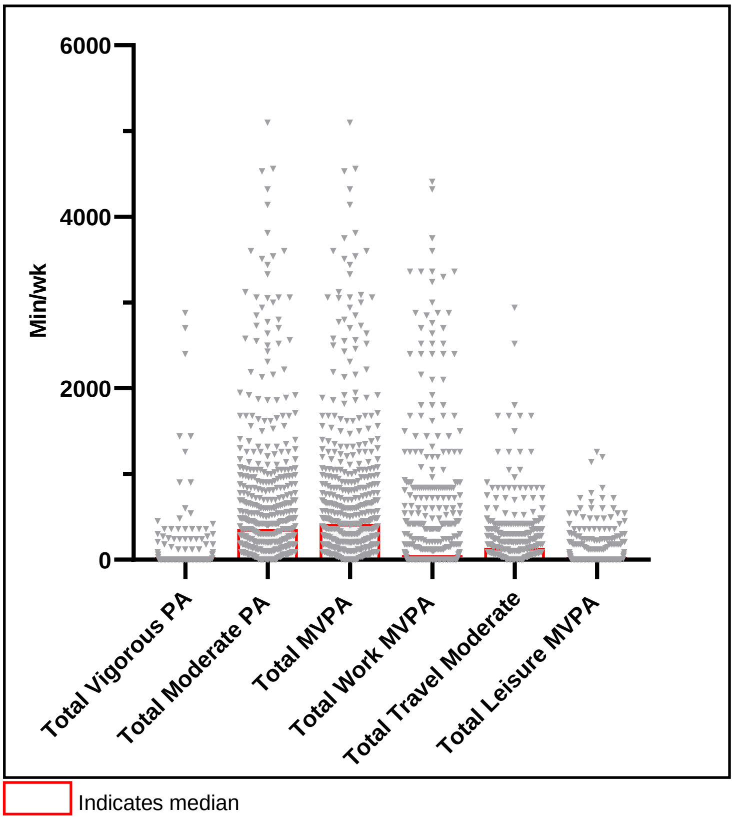

Figure 1: Diagram of the distribution of average weekly physical activity (min/wk) in each domain

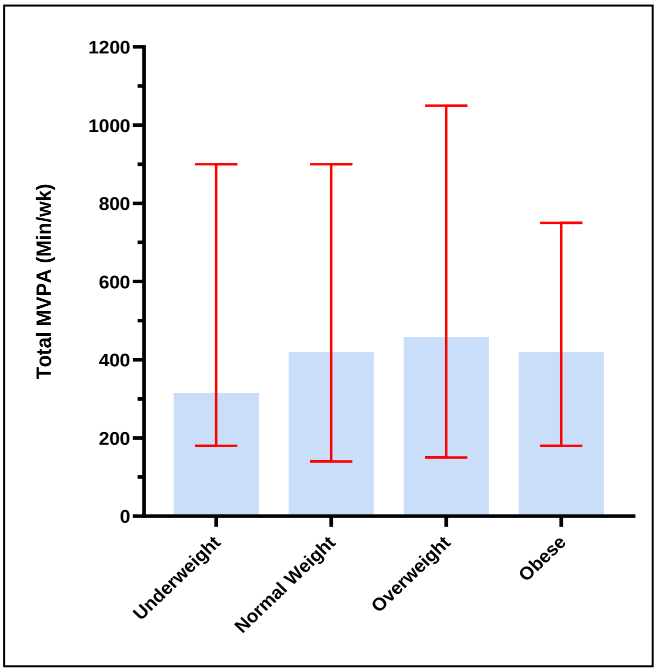

Figure 2: Comparative diagram of time spent in weekly MVPA (min/wk) between BMI category

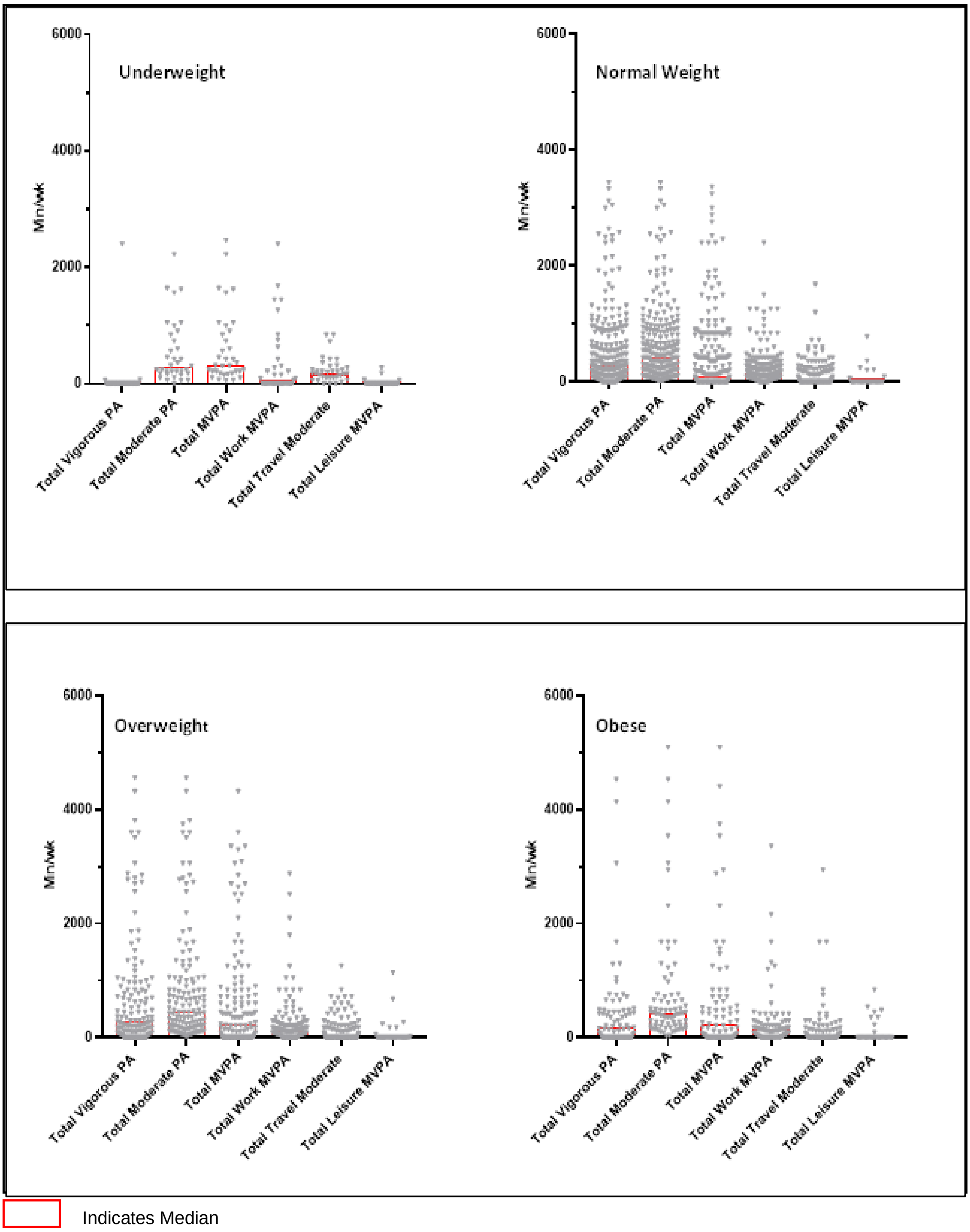

Figure 3. Comparative diagram of the patterns of weekly physical activity (min/wk) between BMI category

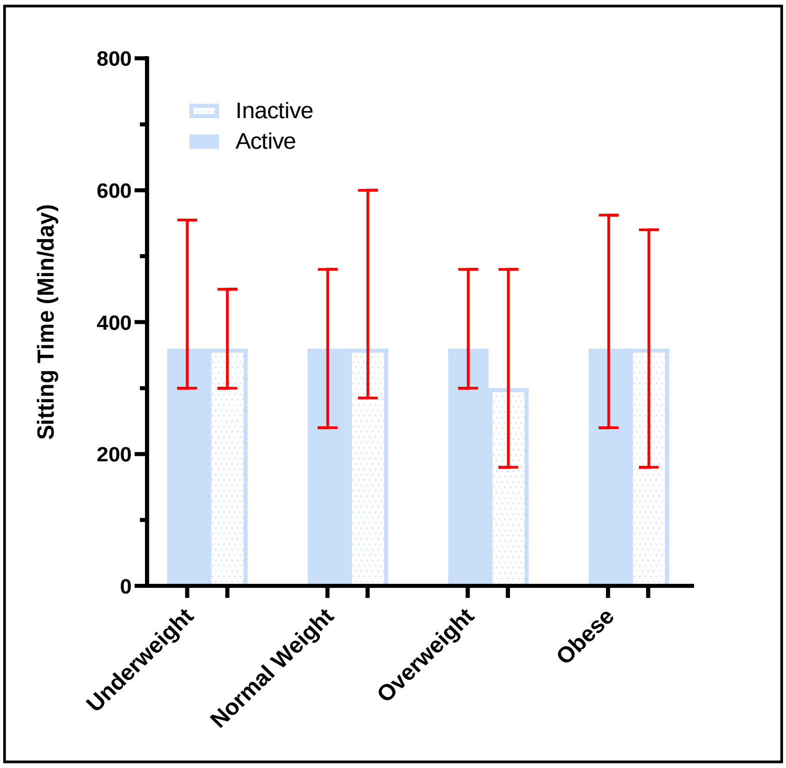

Figure 4: Comparative diagram of sitting time (min/day) for BMI categories between the two groups WHO Active and WHO Inactive

Declarations

Ethics

Ethical approval was granted by the Ethics Committee for Research in Human Subjects at the University of the Witwatersrand (medical), clearance number M160635.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

MVG was involved in data cleaning, performed the statistical analysis, and wrote the report paper. AP and LM were both involved in the conception and design of the research study, assisted, and guided the statistical analysis and the writing and editing of the manuscript.

Acknowledgements

The Biostatisticians at the Wits Health Sciences Research Office for assistance with data analysis.

`

References

1. Alwan A. *Global status report on noncommunicable diseases 2010.* World Health Organization; 2011.

2. Nojilana B, Bradshaw D, Pillay-van Wyk V, et al. Emerging trends in non-communicable disease mortality in South Africa, 1997-2010. *South African medical journal.* 2016;106(5):477-484.

3. *Global Recommendations on Physical Activity for Health 2010.* 2013.

4. E. Anderson JLD. Physical activity, exercise, and chronic diseases: A brief review. *Sports Medicine and Health Science.* 2019;1(1):3-10.

5. Biddle SJH, Bennie JA, Bauman AE, et al. Too much sitting and all-cause mortality: is there a causal link? *BMC Public Health.* 2016;16(1):635.

6. *WHO Guidelines on physical activity and sedentary behaviour for children and adolescents, adults and older adults.* Geneva: World Health Organisation 2020.

7. *South Africa Demographic and Health Survey 2016.* 2019.

8. *South African Demographic and Health Survey 2003.* 2008.

9. Micklesfield LK, Lambert EV, Hume DJ, et al. Socio-cultural, environmental and behavioural determinants of obesity in black South African women. *Cardiovascular journal of Africa.* 2013;24(9-10):369-375.

10. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes Rev.* 2008;9(5):474-488.

11. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. *Preventive medicine.* 1993;22(2):167-177.

12. Lundeen EA, Norris SA, Adair LS, Richter LM, Stein AD. Sex differences in obesity incidence: 20-year prospective cohort in South Africa. *Pediatr Obes.* 2016;11(1):75-80.

13. Hanson SK, Munthali RJ, Micklesfield LK, et al. Longitudinal patterns of physical activity, sedentary behavior and sleep in urban South African adolescents, Birth-To-Twenty Plus cohort. *BMC Pediatrics.* 2019;19(1):241.

14. Richter L, Norris S, Pettifor J, Yach D, Cameron N. Cohort Profile: Mandela's children: the 1990 Birth to Twenty study in South Africa. *Int J Epidemiol.* 2007;36(3):504-511.

15. Said-Mohamed R, Stein AD, Pettifor JM, Norris SA. Sanitation and diarrhoea in infancy and CRP level at 18 years: the birth-to-twenty plus cohort. *Annals of human biology.* 2019;46(5):415-424.

16. Said-Mohamed R, Prioreschi A, Nyati LH, et al. Rural–urban variations in age at menarche, adult height, leg-length and abdominal adiposity in black South African

women in transitioning South Africa. *Annals of human biology.* 2018;45(2):123-132.

17. Prioreschi A, Wrottesley SV, Cohen E, et al. Examining the relationships between body image, eating attitudes, BMI, and physical activity in rural and urban South African young adult females using structural equation modeling. *PLoS One.* 2017;12(11).

18. Prioreschi A, Munthali RJ, Kagura J, et al. The associations between adult body composition and abdominal adiposity outcomes, and relative weight gain and linear growth from birth to age 22 in the Birth to Twenty Plus cohort, South Africa. *PLoS One.* 2018;13(1).

19. Munthali R, Manyema M, Rihlat SM, et al. Body composition and physical activity as mediators in the relationship between socioeconomic status and blood pressure in young South African women: a structural equation model analysis. *BMJ Open.* 2018;8:e023404.

20. Micklesfield LK, Munthali RJ, Prioreschi A, et al. Understanding the relationship between socio-economic status, physical activity and sedentary behaviour, and adiposity in young adult South African women using structural equation modelling. *International journal of environmental research and public health.* 2017;14(10):1271.

21. Dunger D. Examining the relationships between body image, eating attitudes, BMI, and physical activity in rural and urban South African young adult females using structural equation modeling. 2018.

22. *Obesity: preventing and managing the global epidemic.* World Health Organization; 2000.

23. Guthold R, Louazani SA, Riley LM, et al. Physical activity in 22 African countries: results from the World Health Organization STEPwise approach to chronic disease risk factor surveillance. *American journal of preventive medicine.* 2011;41(1):52-60.

24. Bull FC MT, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. Journal of physical activity & health. 2009;6(6):790. *Journal of physical activity & health 2009.* 2009;6(6):790.

25. Gradidge PJ-L, Norris SA, Munthali R, Crowther NJ. Influence of socioeconomic status on changes in body size and physical activity in ageing black South African women. *European Review of Aging and Physical Activity.* 2018;15(1):6.

26. Khan T, Macaulay S, Norris SA, Micklesfield LK, Watson ED. Physical activity and the risk for gestational diabetes mellitus amongst pregnant women living in Soweto: a study protocol. *BMC Women's Health.* 2016;16(1):66.

27. Kader N, Haffejee F. The prevalence of physical activity among South African Indians residing in Durban. *African Journal for Physical Activity and Health Sciences (AJPHES).* 2018;24(4):525-536.

28. Watson ED, Micklesfield LK, van Poppel MNM, Norris SA, Sattler MC, Dietz P. Validity and responsiveness of the Global Physical Activity Questionnaire (GPAQ) in assessing physical activity during pregnancy. *PLoS One.* 2017;12(5):e0177996-e0177996.

29. *Global physical activity questionnaire (GPAQ) analysis guide.* World Health

Organization; 2012.

30. Gradidge PJ-L, Crowther NJ, Chirwa ED, Norris SA, Micklesfield LK. Patterns, levels and correlates of self-reported physical activity in urban black Soweto women. *BMC public health.* 2014;14(1):1.

31. Dickie K, Micklesfield LK, Chantler S, Lambert EV, Goedecke JH. Meeting physical activity guidelines is associated with reduced risk for cardiovascular disease in black South African women; a 5.5-year follow-up study. *BMC public health.* 2014;14(1):1.

32. A. Prioreschi SB, K. Westgate, S. A. Norrisand L. K. Micklesfield. Cardiorespiratory fitness levels and associations with physical activity and body composition in young South African adults from Soweto. *BMC public health.* 2017;17:301.

33. Tudor-Locke CE, Myers AM. Challenges and Opportunities for Measuring Physical Activity in Sedentary Adults *Sports Medicine.* 2001;31(2):91-100.

34. Limb ES, Ahmad S, Cook DG, et al. Measuring change in trials of physical activity interventions: a comparison of self-report questionnaire and accelerometry within the PACE-UP trial. *The international journal of behavioral nutrition and physical activity.* 2019;16(1):10.

35. Harris T, Owen C, Victor C, Adams R, Ekelund U, Cook D. A Comparison of Questionnaire, Accelerometer, and Pedometer: Measures in Older People. *Medicine & Science in Sports & Exercise.* 2009;41(7):1392-1402.

36. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *The Lancet Global health.* 2018;6(10):e1077-e1086.

37. Herrmann SD HK, Der Ananian C, Ainsworth B. . Validity and reliability of the global physical activity questionnaire (GPAQ). *Measurement in Physical Education and Exercise Science.* 2013;17(3):221-235.

38. Larsen BA, Carr LJ, Dunsiger S, Marcus BH. Effect of a moderate-intensity demonstration walk on accuracy of physical activity self-report. *J Exerc Sci Fit.* 2017;15(1):1-7.

39. Tudor-Locke C, Han H, Aguiar EJ, et al. How fast is fast enough? Walking cadence (steps/min) as a practical estimate of intensity in adults: a narrative review. *British Journal of Sports Medicine.* 2018;52(12):776.

40. Slaght J, Sénéchal M, Hrubeniuk TJ, Mayo A, Bouchard DR. Walking Cadence to Exercise at Moderate Intensity for Adults: A Systematic Review. *Journal of Sports Medicine.* 2017;2017:4641203.

41. Ekelund U, Ward HA, Norat T, et al. Physical activity and all-cause mortality across levels of overall and abdominal adiposity in European men and women: the European Prospective Investigation into Cancer and Nutrition Study (EPIC). *Am J Clin Nutr.* 2015;101(3):613-621.

42. Micklesfield LK, Kagura J, Munthali R, et al. Demographic, socio-economic and behavioural correlates of BMI in middle-aged black men and women from urban

Johannesburg, South Africa. *Global health action.* 2018;11(sup2):1448250.

43. Okorodudu DO, Jumean MF, Montori VM, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systematic review and meta-analysis. *International journal of obesity (2005).* 2010;34(5):791-799.

44. Kruger HS, Venter CS, Vorster HH, Margetts BM. Physical inactivity is the major determinant of obesity in black women in the North West Province, South Africa: the THUSA study. Transition and Health During Urbanisation of South Africa. *Nutrition (Burbank, Los Angeles County, Calif).* 2002;18(5):422-427.

45. Rush EC, Goedecke JH, Jennings C, et al. BMI, fat and muscle differences in urban women of five ethnicities from two countries. *International journal of obesity (2005).* 2007;31(8):1232-1239.

46. Gradidge PJ-L, Cohen E. Body mass index and associated lifestyle and eating behaviours of female students at a South African university. *South African Journal of Clinical Nutrition.* 2018;31(4):89-91.

47. Dugas LR, Bovet P, Forrester TE, et al. Comparisons of intensity-duration patterns of physical activity in the US, Jamaica and 3 African countries. *BMC Public Health.* 2014;14(1):882.

48. Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet.* 2016;388(10051):1302-1310.

49. Biddle SJH, García Bengoechea E, Pedisic Z, Bennie J, Vergeer I, Wiesner G. Screen Time, Other Sedentary Behaviours, and Obesity Risk in Adults: A Review of Reviews. *Current obesity reports.* 2017;6(2):134-147

Additional information

APPENDIX A: Turnitin Report

0405973y:Final_Draft_for_Maxine_van_Greenen_submitted.docx

ORIGINALITY REPORT

10%	7%	8%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	wiredspace.wits.ac.za Internet Source	3%
2	Submitted to University of Glamorgan Student Paper	1%
3	www.scribd.com Internet Source	1%
4	www.mdpi.com Internet Source	1%
5	Submitted to Associatie K.U.Leuven Student Paper	1%
6	bmcpublichealth.biomedcentral.com Internet Source	1%
7	worldwidescience.org Internet Source	1%
8	Gradidge, Philippe Jean-Luc, Nigel J Crowther, Esnat D Chirwa, Shane A Norris, and Lisa K Micklesfield. "Patterns, levels and correlates of self-reported physical activity in urban black	1%

Soweto women", BMC Public Health, 2014.
Publication

9	"Sedentary Behaviour Epidemiology", Springer Science and Business Media LLC, 2018 Publication	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		

APPENDIX B: Ethics Clearance Certificate

R14/49 Dr Maxine Bernadette van Greenen

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M160635

NAME: **(Principal Investigator)**	Dr Maxine Bernadette van Greenen
DEPARTMENT:	Paediatrics and Child Health MRC/Wits Developmental Pathways Health Research Unit
PROJECT TITLE:	A Comparison of Self-Reported Physical Activity Levels and Patterns between Rural and Urban Black South African Young Adult Women
DATE CONSIDERED:	24/06/2016
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Alessandra Prioreschi
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	05/08/2016

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004, 10th floor, Senate House/2nd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in June and will therefore be due in the month of June each year.

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

I

APPENDIX C: BMC Public Health Journal Guideline

Submission guidelines: BMC Public Health- Preparing your manuscript Below are the main submission guideline for submitting a research Article in BMC Public Health. The complete submission guidelines can be found at: https://bmcpublichealth.biomedcentral.com/submission-guidelines/preparing-yourmanuscript/research-article The information below details the section headings that you should include in your manuscript and what information should be within each section. Please note that your manuscript must include a 'Declarations' section including all of the subheadings (please see below for more information). Title page The title page should: • present a title that includes, if appropriate, the study design e.g.: o "A versus B in the treatment of C: a randomized controlled trial", "X is a risk factor for Y: a case control study", "What is the impact of factor X on subject Y: A systematic review" o or for non-clinical or non-research studies a description of what the article reports • list the full names and institutional addresses for all authors o if a collaboration group should be listed as an author, please list the Group name as an author. If you would like the names of the individual members of the Group to be searchable through their individual PubMed records, please include this information in the “Acknowledgements” section in accordance with the instructions below • indicate the corresponding author Abstract The Abstract should not exceed 350 words. Please minimize the use of abbreviations and do not cite references in the abstract. Reports of randomized controlled trials should follow the CONSORT extension for abstracts. The abstract must include the following separate sections: • Background: the context and purpose of the study • Methods: how the study was performed and statistical tests used • Results: the main findings • Conclusions: brief summary and potential implications • Trial registration: If your article reports the results of a health care intervention on human participants, it must be registered in an appropriate registry and the registration number and date of registration should be in stated in this section. If it was not registered prospectively (before enrolment of the first participant), you should include the words 'retrospectively registered'. See our editorial policies for more information on trial registration Keywords Three to ten keywords representing the main content of the article. Background the Background section should explain the background to the study, its aims, a summary of the existing literature and why this study was necessary or its contribution to the field. Methods The methods section should include: • the aim, design and setting of the study • the characteristics of participants or description of materials • a clear description of all processes, interventions, and comparisons. Generic drug names should generally be used. When proprietary brands are used in research, include the brand names in parentheses • the type of statistical analysis used, including a power calculation if appropriate Results This should include the findings of the study including, if appropriate, results of statistical analysis which must be included either in the text or as tables and figures. Discussion This section should discuss the implications of the findings in context of existing research and highlight limitations of the study. Conclusions This should state clearly the main conclusions and provide an explanation of the importance and relevance of the study reported. List of abbreviations If abbreviations are used in the text they should be defined in the text at first use, and a list of abbreviations should be provided.

APPENDIX D: Research Protocol

The association between self-reported physical activity levels and patterns and BMI of urban black South African young adult women

Student: Dr Maxine Bernadette van Greenen, University of the Witwatersrand

Department of Paediatrics and Child Health

Student Number: 0405973Y

Qualification: MBBCH(Wits), BSc Dietetics(KZN), Postgrad Dipl Hosp Diet(UP)

Degree protocol is submitted for: MMed(Paeds)

Supervisor 1: Dr Alessandra Prioreschi, PhD

Supervisor 2: Assoc Prof Lisa K Micklesfield, PhD

TABLE OF CONTENTS

ABBREVIATIONS

WHO	World Health Organization
PA	Physical Activity
BMI	Body Mass Index
SADHS	South African Demographic and Health Survey
SANHANES	The South African National Health and Nutrition Examination Survey
BT20	Birth to Twenty
NCDs	Non-communicable diseases
CVD	Cardiovascular disease
T2DM	Type 2 diabetes mellitus
GPAQ	Global Physical Activity Questionnaire
MET	Metabolic Equivalents
MVPA	Moderate-Vigorous-Physical activity
USA	United States of America

1. TITLE

The association between self-reported physical activity levels and patterns and BMI of urban black South African young adult women.

2. STUDY QUESTIONS

2.1 Is there an association between physical activity (PA) and body mass index (BMI) in urban black women in South Africa?

2.2 Are the different domains of PA i.e.: PA at work, walking for transport and recreational PA associated with BMI?

2.3 Is there an association between sedentary behaviour and BMI?

3. INTRODUCTION

The WHO has stated that physical inactivity, overweight and obesity have become a global epidemic[22]. Obesity and physical inactivity are known risk factors for non-communicable diseases (NCDs) such as cardiovascular disease (CVD), Type 2 diabetes mellitus (T2DM), respiratory diseases and cancer [50,51]. In 2004 NCDs caused 28% of the total burden of disease measured by disability adjusted life years (DALYs)[52]. Globally, out of every 10 deaths, 6 deaths are due to NCDs; 3 to communicable diseases, reproductive or nutritional conditions; and 1 to injuries[52]. The morbidity and mortality from NCDs is increasing and the WHO estimates the burden of NCDs in South Africa to be two to three times higher than in developed counties[52]. Mayosi et al, in 2009 stated that this increase will have a major impact on the delivery of acute and chronic health care services in South Africa[51].

PA is fundamental for weight control and energy balance[52,53]. Physical inactivity has been identified as the fourth leading risk factor for global mortality as well as a modifiable risk factor for NCDs[3]. The 2003 South African Demographic and Healthy Survey (SADHS) reported that 14% of women (15-49 years) were classified as active compared with 24% of men (15-59 years). The survey showed that PA decreased with increasing age in both genders. For women, there was a 10% difference in the levels of activity between younger (15-24 years 18%) and older (65+ years 8%) individuals. Other pertinent findings were that the prevalence of inactivity was higher in the urban compared to non-urban adult populations. In the urban setting, the prevalence of physical inactivity was 49% for men and 66% for women compared with inactivity levels of 46% for men and 59% for women in non-urban dwellings. The data on PA levels in the SADHS was obtained using the Global Physical Activity Questionnaire (GPAQ). Similarly, Cook et al in 2009 confirmed, using an objective measure to assess PA, that black South African urban dwelling adult women are less physically active than rural adult women, the latter group accumulated higher levels of PA by participating in subsistence related PA (activity related to securing work, food, water and shelter) and walking[54].

The WHO recently developed a document, The Global Recommendations on Physical Activity for Health, to focus on the primary prevention of NCDs through PA at a population level. The target audience for these recommendations are policy-makers, with the aim to assist in the development of public health policies specifically addressing the issue of physical inactivity in their respective countries. These recommendations of physical activity for health take into account the frequency, duration, intensity, type and total amount of physical activity and are defined as follows: For adults aged 18–64 years participation in physical activity for health should be a minimum of 150 minutes of moderate-intensity aerobic PA per week or a minimum of 75 minutes of vigorous-intensity aerobic PA per week or an equivalent combination of moderate and vigorous-intensity activity (MVPA). Aerobic activity should be performed in sessions of a minimum of10 minute. The aerobic activity should include muscle-strengthening activity involving major muscle groups on 2 or more days a week. Adults who meet these guidelines are classified as sufficiently active or sufficiently inactive if the guidelines are not met[3].

There are many instruments and tools that can be used to measure PA, including direct, objective, and subjective methods. Self-reported PA questionnaires, PA logs, PA diaries and recall are examples of subjective methods. Self-report PA questionnaires are low cost, easy to administer and adaptable to different cultures and languages, especially when collecting PA data from large population groups. The GPAQ was developed as part of The WHO StepWise approach to chronic disease risk factor surveillance (STEPS) to assess PA, especially in low- and middle-income countries. The advantage of the GPAQ is that it captures PA performed in the different domains, namely: work, transport, and leisure time. This is an important consideration when assessing PA in developing countries because research suggests that occupational, domestic and transport related activities may contribute more to overall energy expenditure than leisure time or recreational activity in these settings[23,55,56]. In 2009 the GPAQ was validated internationally[55]. In Africa, GPAQ has been used successfully to collect data on PA in different population groups of varying ages from 25-50 years old [23,30,31].

Besides physical inactivity, South Africans have not been immune to the worldwide overweight and obesity epidemic. Historically the dramatic increase in the overweight and obesity epidemic has been more evident in economically developed and urbanised populations[3,57]. Data from The South African National Health and Nutrition Examination Survey (SANHANES) of 2012 indicates that nearly 7 out of 10 adult women and 1 in 3 adult men are overweight or obese[58]. The SADHS reported that the population group at highest risk for obesity were black urban dwelling females. Out of all the race groups black women had the highest prevalence of obesity at 28.5%, with a prevalence of 31%

in urban black females. For females, overweight and obesity starts at a young age, in the SADHS 10% of females (15-24 years) were obese[8]. The latter is an important finding because studies have consistently found that overweight and obesity in childhood and adolescence tracks into adulthood, with significant implications for the burden of disease in adulthood attributed to NCD's[59,60]. In South Africa, findings from the 2012 SANHANES showed a combined prevalence of overweight and obesity of 14.2% for children (6–14 years), with the highest rates in black girls (6-14 years) 7,6% and 2,1% respectively. This is one of the highest rates of childhood overweight and obesity in Africa. These figures are comparable to the USA, a developed country, where the prevalence of overweight and obesity in 6–11 year-olds was 15.7% in 2009–2010[58]. There are also differences in the prevalence of overweight and obesity between boys and girls. In adolescent studies Lundeen et al (2016) reported that in an urban setting boys and girls have different patterns in the incidence of overweight and obesity. For boys, the combined prevalence of overweight and obesity declined steadily and by late adolescence (16-18years) it was less than the 16% expected for a normal distribution. Compared to the girls, the overall prevalence continued to rise reaching 11% greater than 16% expected for a normal distribution[61]. This study suggested that the prevalence of overweight and obesity in boys does not represent a significant public health concern and obesity in females is presenting in adolescence. Overweight and obesity are classified using the BMI classification, where obesity is defined as a BMI of ≥ 30kg/m^2.

An important point to highlight in the discussion of the prevalence of overweight and obesity, and the burden of disease from NCDs is that the nutritional status of the South African population is complex, because the country is in a health transition[50,51]. As a result South Africa is a country characterised by undernutrition in children and increasing overweight and obesity in both children and adults[50]. A systemic review by Said-Mohamed et al in 2015 reported that stunting persists in South African children despite advances in economic growth, political and social transitions, and national nutritional programs[62]. This reported unchanged prevalence of stunting in South African children increases the burden of NCDs because it has been reported that early life malnutrition is associated with an increased risk of obesity and cardio- metabolic disease in adult life[62,63].

Puoane et al have suggested that the primary prevention of obesity should start at a young age, particularly in girls[50]. Transitioning from a rural to urban area is associated with lifestyle and dietary changes[9]. During urbanisation there is a tendency to adopt a more Westernised lifestyle including consuming a diet higher in energy, sugar and fat, as well as physical inactivity and increased sedentary behaviour[9]. In a South African study of black women in the North West Province it was found that physical inactivity showed a strong negative association with obesity as measured by BMI, and that women with higher incomes and lower PA were at the greatest risk of increased BMI[64]. Socio-economic status, age and cultural beliefs regarding body size are also possible contributing factors to the higher prevalence of obesity in black South African women[9,31,50,58]. According to Sedibe et al adolescent females (18 years old) in an urban setting in South Africa in 2014 spent more time in sedentary behaviour and were not physically active at school or at home, with most PA associated with doing household chores or partaking in leisure time PA such as social dancing[65]. As adolescents, complete school, and transition into young adult life they tend to spend more time away from home either engaged in employment or further education. It would be interesting to see if an increase in age and independence is associated with a change in the levels and patterns of PA of young adult woman compared to adolescent girls as reported in the aforementioned studies[65,66].

4. AIMS

The aim of this study is to determine whether self-reported PA levels and patterns of young adult urban black South African women are associated with overweight and obesity, as measured by BMI.

5. METHODOLOGY

5.1 Study design and participants

This cross-sectional study will include 500 black female participants between the age range 22-23 years from the Birth to Twenty (BT20) study. Only participants who completed the BT20+ questionnaire and had anthropometric assessments will be included. This age range was pre-determined and set as an assessment time point by the BT20+ study. BT20+ began in 1990 and is Africa's largest and longest running large scale longitudinal study of child and adolescent health and development. This is a birth cohort study of 3273 singleton new-born infants born from April 23 - June 6 1990 to women residing in Soweto-Johannesburg, an urban area. The cohort included all South African race groups, however whites were under represented. Data was collected during a 7-week enrolment period from pregnant women attending public antenatal clinics who were predicted to deliver during the 7-week period. The infants and their families were followed up for 22-23 years. The time points for the assessments and surveys was at birth, age 6 months and then yearly, with the latest assessment done at 22-23 years. The surveys were in the form of questionnaires that covered topics such as the physical health and development of the child, his or her environment, education, nutrition, socioeconomic class, and cognitive development. As the children reached adolescence surveys also monitored their opinion on politics, Africa, and other social opinions[14].

5.2 Measurements

Data will be extracted from a questionnaire that was developed specifically for BT20+ study. The questionnaire comprised of six sections covering: socio-economic factors and life events, self-reported PA using the GPAQ, body image, general health, access to health services, and anthropometric measurements. The questionnaire was completed in the form of face to face interviews in the participants' own language, conducted by trained field workers. To facilitate understanding show cards were used to explain the different types of PA for each domain. The GPAQ section comprised 16 questions. The questions are grouped into PA domains activity at work, transport, and recreational activity. Work and recreational activity are each divided into two sub-domains defined by the intensity of the activity: vigorous and moderate. Travel is assessed as walking or cycling to and from places for work, shopping, and leisure. Sedentary behaviour is assessed as sitting time at home, work, during travel and leisure time.

The data sheet attached (Appendix 1) outlines the variables used in this study. The variables are study number, date of birth, weight, height and the GPAQ domains: activity at work (work vigorous and work moderate), travel, recreational activity (recreational vigorous and recreational moderate) and sedentary behaviour. According to the participant's response the PA frequency was recorded as days/week, hours/day, and minutes/day. Sedentary behaviour was recorded as hours/day and minutes/day.

5.3 Physical Activity

For each of the PA domains: vigorous work, moderate work, travel, vigorous recreational and moderate recreational, total PA time is recorded as minutes/week and PA intensity recorded as total moderate, total vigorous and total MVPA. Travel is moderate intensity PA. PA intensity in the domains will be defined using metabolic equivalents (METS) as met/minutes/week. MET is the ratio of a person's working metabolic rate relative to the resting metabolic rate. One MET is defined as the energy cost of sitting quietly and is equivalent to a caloric consumption of 1 kcal/kg/hour. The total PA time in minutes/week and the MET values per activity are multiplied together to give met/ minutes/week. Moderate activity is allocated a MET value of four and vigorous physical activity a value of eight[29].

Participants will be classified as physically active or physically inactive according to the WHO criteria. WHO active is defined as taking part in moderate physical activity for a total of ≥150 minutes/ week (≥5 days/week) or vigorous PA ≥75 minutes/week (≥3 days/week) or a combination of moderate-vigorous PA (MVPA) ≥ 150 minutes/week (≥5 days per week). Participants who do not meet these criteria for PA will be classified as WHO inactive[29].

5.4 Anthropometric measurements and BMI

Weight was measured to the nearest 0.1kg using a standard electronic scale. Height was measured to the nearest millimetre (mm) using a stadiometer. During the measurements, the participants wore light clothes and no shoes. Body mass index (BMI) is calculated as weight in kilograms divided by the square of height in meters and will be classified as follows:

• BMI <18.5, underweight range

• BMI 18.5 to 24.9, normal or healthy weight range.

• BMI 25.0 to 29.9, overweight range.

• BMI ≥ 30.0, obese range[22]

5.5 Data Analysis

The statistical package STATA will be used to analyse the data. For descriptive analysis means, standard deviations(SD) and percentages will be reported for continuous and categorical variables, respectively. A Chi squared test will be used to determine whether a significant association exists between categorical data such as the BMI categories and WHO active or inactive variables. A t-test will be used to examine whether there is a difference between the two categories WHO active and inactive and the quantitative outcome of BMI. The main purpose of this study is to determine the relationship between the BMI outcome, and the exposure variable MVPA (minutes/week) using simple linear regression. Logistic regression analysis will then be used to determine the relationship between PA, sedentary behaviour, and BMI.

6. ETHICS

Ethical approval for the BT20+ study has already been obtained. Clearance number: M120138. This study proposal has been submitted to the Ethics Committee for Research in Human Subjects at the University of the Witwatersrand (medical) and ethical approval has been granted, clearance number M160635. Permission to use the data and conduct the study will be obtained from the research committee of BT20+.

7. LIMITATIONS

The basis of data collection for this study will be a retrospective review and will depend entirely on the quality of record keeping. The GPAQ questionnaire is a subjective self-report and is prone to bias and may be unreliable. Self-report PA questionnaires tend to either over or underestimate true PA, energy expenditure and rates of inactivity. However GPAQ has been validated for use in South Africa and has also been used internationally for monitoring PA in population health surveillance[3,55]. The use of self-report questionnaires is associated with inaccurate memory recall and participants may be inclined to give socially desirable answers. Limiting the study population to only black females is not nationally representative and may not represent PA levels and patterns of the whole country. However, information obtained from this study may still provide valuable data in a population who is at risk of NCDs and obesity.

8. BUDGET

Stationary, printing, and binding costs will be incurred by the researcher.

9. TIMELINE

	Sep-Dec 2015	Jan-April 2016	May 2016	June 2016	July-Aug 2016	Aug-Dec 2016
Literature Review						
Preparing Protocol						
Protocol Submission and Ethics application						
Data analysis and write up						

10. REFERENCES

1. Nojilana B, Bradshaw D, Pillay-van Wyk V, et al. Emerging trends in non-communicable disease mortality in South Africa, 1997-2010. *South African medical journal.* 2016;106(5):477-484.

2. Alwan A. *Global status report on noncommunicable diseases 2010.* World Health Organization; 2011.

3. *Global Recommendations on Physical Activity for Health 2010.* 2013.

4. E. Anderson JLD. Physical activity, exercise, and chronic diseases: A brief review. *Sports Medicine and Health Science.* 2019;1(1):3-10.

5. Biddle SJH, Bennie JA, Bauman AE, et al. Too much sitting and all-cause mortality: is there a causal link? *BMC Public Health.* 2016;16(1):635.

6. *WHO Guidelines on physical activity and sedentary behaviour for children and adolescents, adults and older adults.* Geneva: World Health Organisation 2020.

7. *South Africa Demographic and Health Survey 2016.* 2019.

8. *South African Demographic and Health Survey 2003.* 2008.

9. Micklesfield LK, Lambert EV, Hume DJ, et al. Socio-cultural, environmental and behavioural determinants of obesity in black South African women. *Cardiovascular journal of Africa.* 2013;24(9-10):369-375.

10. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes Rev.* 2008;9(5):474-488.

11. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. *Preventive medicine.* 1993;22(2):167-177.

12. Lundeen EA, Norris SA, Adair LS, Richter LM, Stein AD. Sex differences in obesity incidence: 20-year prospective cohort in South Africa. *Pediatr Obes.* 2016;11(1):75-80.

13. Hanson SK, Munthali RJ, Micklesfield LK, et al. Longitudinal patterns of physical activity, sedentary behavior and sleep in urban South African adolescents, Birth-To-Twenty Plus cohort. *BMC Pediatrics.* 2019;19(1):241.

14. Richter L, Norris S, Pettifor J, Yach D, Cameron N. Cohort Profile: Mandela's children: the 1990 Birth to Twenty study in South Africa. *Int J Epidemiol.* 2007;36(3):504-511.

15. Said-Mohamed R, Stein AD, Pettifor JM, Norris SA. Sanitation and diarrhoea in infancy and CRP level at 18 years: the birth-to-twenty plus cohort. *Annals of human biology.* 2019;46(5):415-424.

16. Said-Mohamed R, Prioreschi A, Nyati LH, et al. Rural–urban variations in age at menarche, adult height, leg-length and abdominal adiposity in black South African women in transitioning South Africa. *Annals of human biology.* 2018;45(2):123-132.

17. Prioreschi A, Wrottesley SV, Cohen E, et al. Examining the relationships between body image, eating attitudes, BMI, and physical activity in rural and urban South African young adult females using structural equation modeling. *PLoS One.* 2017;12(11).

18. Prioreschi A, Munthali RJ, Kagura J, et al. The associations between adult body composition and abdominal adiposity outcomes, and relative weight gain and linear growth from birth to age 22 in the Birth to Twenty Plus cohort, South Africa. *PLoS One.* 2018;13(1).

19. Munthali R, Manyema M, Rihlat SM, et al. Body composition and physical activity as mediators in the relationship between socioeconomic status and blood pressure in young South African women: a structural equation model analysis. *BMJ Open.* 2018;8:e023404.

20. Micklesfield LK, Munthali RJ, Prioreschi A, et al. Understanding the relationship between socio-economic status, physical activity and sedentary behaviour, and adiposity in young adult South African women using structural equation modelling. *International journal of environmental research and public health.* 2017;14(10):1271.

21. Dunger D. Examining the relationships between body image, eating attitudes, BMI, and physical activity in rural and urban South African young adult females using structural equation modeling. 2018.

22. *Obesity: preventing and managing the global epidemic.* World Health Organization; 2000.

23. Guthold R, Louazani SA, Riley LM, et al. Physical activity in 22 African countries: results from the World Health Organization STEPwise approach to chronic disease risk factor surveillance. *American journal of preventive medicine.* 2011;41(1):52-60.

24. Bull FC MT, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. Journal of physical activity & health. 2009;6(6):790. *Journal of physical activity & health 2009.* 2009;6(6):790.

25. Gradidge PJ-L, Norris SA, Munthali R, Crowther NJ. Influence of socioeconomic status on changes in body size and physical activity in ageing black South African women. *European Review of Aging and Physical Activity.* 2018;15(1):6.

26. Khan T, Macaulay S, Norris SA, Micklesfield LK, Watson ED. Physical activity and the risk for gestational diabetes mellitus amongst pregnant women living in Soweto: a study protocol. *BMC Women's Health.* 2016;16(1):66.

27. Kader N, Haffejee F. The prevalence of physical activity among South African Indians residing in Durban. *African Journal for Physical Activity and Health Sciences (AJPHES).* 2018;24(4):525-536.

28. Watson ED, Micklesfield LK, van Poppel MNM, Norris SA, Sattler MC, Dietz P. Validity and responsiveness of the Global Physical Activity Questionnaire (GPAQ) in assessing physical activity during pregnancy. *PLoS One.* 2017;12(5):e0177996-e0177996.

29. *Global physical activity questionnaire (GPAQ) analysis guide.* World Health Organization; 2012.

30. Gradidge PJ-L, Crowther NJ, Chirwa ED, Norris SA, Micklesfield LK. Patterns, levels and correlates of self-reported physical activity in urban black Soweto women. *BMC public health.* 2014;14(1):1.

31. Dickie K, Micklesfield LK, Chantler S, Lambert EV, Goedecke JH. Meeting physical activity guidelines is associated with reduced risk for cardiovascular disease in black South African women; a 5.5-year follow-up study. *BMC public health.* 2014;14(1):1.

32. A. Prioreschi SB, K. Westgate, S. A. Norrisand L. K. Micklesfield. Cardiorespiratory fitness levels and associations with physical activity and body composition in young South African adults from Soweto. *BMC public health.* 2017;17:301.

33. Tudor-Locke CE, Myers AM. Challenges and Opportunities for Measuring Physical Activity in Sedentary Adults *Sports Medicine.* 2001;31(2):91-100.

34. Limb ES, Ahmad S, Cook DG, et al. Measuring change in trials of physical activity interventions: a comparison of self-report questionnaire and accelerometry within the PACE-UP trial. *The international journal of behavioral nutrition and physical activity.* 2019;16(1):10.

35. Harris T, Owen C, Victor C, Adams R, Ekelund U, Cook D. A Comparison of Questionnaire, Accelerometer, and Pedometer: Measures in Older People. *Medicine & Science in Sports & Exercise.* 2009;41(7):1392-1402.

36. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *The Lancet Global health.* 2018;6(10):e1077-e1086.

37. Herrmann SD HK, Der Ananian C, Ainsworth B. . Validity and reliability of the global physical activity questionnaire (GPAQ). *Measurement in Physical Education and Exercise Science.* 2013;17(3):221-235.

38. Larsen BA, Carr LJ, Dunsiger S, Marcus BH. Effect of a moderate-intensity demonstration walk on accuracy of physical activity self-report. *J Exerc Sci Fit.* 2017;15(1):1-7.

39. Tudor-Locke C, Han H, Aguiar EJ, et al. How fast is fast enough? Walking cadence (steps/min) as a practical estimate of intensity in adults: a narrative review. *British Journal of Sports Medicine.* 2018;52(12):776.

40. Slaght J, Sénéchal M, Hrubeniuk TJ, Mayo A, Bouchard DR. Walking Cadence to Exercise at Moderate Intensity for Adults: A Systematic Review. *Journal of Sports Medicine.* 2017;2017:4641203.

41. Ekelund U, Ward HA, Norat T, et al. Physical activity and all-cause mortality across levels of overall and abdominal adiposity in European men and women: the European Prospective Investigation into Cancer and Nutrition Study (EPIC). *Am J Clin Nutr.* 2015;101(3):613-621.

42. Micklesfield LK, Kagura J, Munthali R, et al. Demographic, socio-economic and behavioural correlates of BMI in middle-aged black men and women from urban Johannesburg, South Africa. *Global health action.* 2018;11(sup2):1448250.

43. Okorodudu DO, Jumean MF, Montori VM, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systematic review and meta-analysis. *International journal of obesity (2005).* 2010;34(5):791-799.

44. Kruger HS, Venter CS, Vorster HH, Margetts BM. Physical inactivity is the major determinant of obesity in black women in the North West Province, South Africa: the THUSA study. Transition and Health During Urbanisation of South Africa. *Nutrition (Burbank, Los Angeles County, Calif).* 2002;18(5):422-427.

45. Rush EC, Goedecke JH, Jennings C, et al. BMI, fat and muscle differences in urban women of five ethnicities from two countries. *International journal of obesity (2005).* 2007;31(8):1232-1239.

46. Gradidge PJ-L, Cohen E. Body mass index and associated lifestyle and eating behaviours of female students at a South African university. *South African Journal of Clinical Nutrition.* 2018;31(4):89-91.

47. Dugas LR, Bovet P, Forrester TE, et al. Comparisons of intensity-duration patterns of physical activity in the US, Jamaica and 3 African countries. *BMC Public Health.* 2014;14(1):882.

48. Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet.* 2016;388(10051):1302-1310.

49. Biddle SJH, García Bengoechea E, Pedisic Z, Bennie J, Vergeer I, Wiesner G. Screen Time, Other Sedentary Behaviours, and Obesity Risk in Adults: A Review of Reviews. *Current obesity reports.* 2017;6(2):134-147.

50. Puoane T, Steyn K, Bradshaw D, et al. Obesity in South Africa: the South African demographic and health survey. *Obes Res.* 2002;10.

51. Mayosi BM, Flisher AJ, Lalloo UG, Sitas F, Tollman SM, Bradshaw D. The burden of non-communicable diseases in South Africa. *The Lancet.*374(9693):934-947.

52. Mathers C, Fat DM, Boerma JT. *The global burden of disease: 2004 update.* World Health Organization; 2008.

53. *The world health report 2002: reducing risks, promoting healthy life.* World Health Organization; 2002.

54. Cook I, Alberts M, Brits JS, Choma SR, Mkhonto SS. Descriptive epidemiology of ambulatory activity in rural, black South Africans. *Med Sci Sports Exerc.* 2010;42(7):1261-1268.

55. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *Journal of physical activity & health.* 2009;6(6):790.

56. Armstrong T, Bull F. Development of the world health organization global physical activity questionnaire (GPAQ). *Journal of Public Health.* 2006;14(2):66-70.

57. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity.* 2006;1(1):11-25.

58. Shisana O. *The South African National Health and Nutrition Examination Survey: SANHANES-1.* HSRC press; 2014.

59. Singh AS, Mulder C, Twisk JW, Van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obesity reviews.* 2008;9(5):474-488.

60. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. *Preventive medicine.* 1993;22(2):167-177.

61. Lundeen E, Norris S, Adair LS, Richter L, Stein A. Sex differences in obesity incidence: 20-year prospective cohort in South Africa. *Pediatric obesity.* 2016;11(1):75-80.

62. Said-Mohamed R, Micklesfield LK, Pettifor JM, Norris SA. Has the prevalence of stunting in South African children changed in 40 years? A systematic review. *BMC public health.* 2015;15(1):534.

63. Hales CN, Barker DJ. The thrifty phenotype hypothesis. *British medical bulletin.* 2001;60(1):5-20.

64. Kruger HS, Venter CS, Vorster HH, Margetts BM. Physical inactivity is the major determinant of obesity in black women in the North West province, South Africa: the THUSA study. *Nutrition.* 2002;18(5):422-427.

65. Sedibe MH, Feeley AB, Voorend C, Griffiths PL, Doak CM, Norris SA. Narratives of urban female adolescents in South Africa: dietary and physical activity practices in an obesogenic environment. *South African Journal of Clinical Nutrition.* 2014;27(3):114-119.

66. Micklesfield LK, Pedro TM, Kahn K, et al. Physical activity and sedentary behavior among adolescents in rural South Africa: levels, patterns and correlates. *BMC public health.* 2014;14(1):1.

APPENDIX 1 Data Sheet

DATA SHEET

STUDY NUMBER BT20 ID	
DATE OF BIRTH	
ANTHROPOMETRY	
Height (cm)	
Weight (kg)	
BODY MASS INDEX (kg/m^2)	

GPAQ (Physical activity)			
Activity at work			
	Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, childcare, or seeking employment.		
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *carrying or lifting heavy loads, digging or construction work* for **at least 10 minutes** continuously? (*USE SHOWCARDS*)	YES ....1 NO..2	—➢4
2	In **a typical week**, how many days do you do vigorous-intensity activities as part of your work?	DAYS_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
3	How much time do you spend doing vigorous-intensity activities at work on a typical day?	HOURS________ MINUTES___________	
4	Does your work involve moderate-intensity activities that cause small increases in breathing or heart rate such as brisk walking *or carrying light loads* for **at least 10 minutes** continuously? *(USE SHOWCARDS)*	YES ....1 NO……………………………………….2	—➢7
5	In **a TYPICAL week**, how many days do you do moderate-intensity activities as part of your work?	DAYS_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
6	How much time do you spend doing moderate-intensity activities at work on a typical day?	HOURS________MINUTES________	

Travel to and from places			
	The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example, to work, for shopping, to market, or to church.		
7	Do you walk or use a bicycle for **at least 10 minutes** continuously to get to and from places?	YES ....1 NO..2	—➢10
8	In **a typical week**, how many days do you walk or bicycle for at least 10 minutes to get to and from places?	DAYS_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
9	How much time do you spend walking or bicycling for travel on a typical day?	HOURS________MINUTES________	
Recreational activities			
	The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness, and recreational activities (leisure).		
10	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like *running or soccer*, for at least 10 minutes continuously? (USE SHOWCARD)	YES ....1 NO..2	—➢13
11	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	DAYS_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
12	How much time do you spend doing vigorous-intensity sports, fitness, or recreational activities on a typical day?	HOURS________MINUTES________	
13	Do you do any moderate-intensity sports, fitness or recreational (*leisure*) activities that causes a small increase in breathing or heart rate such as brisk walking, cycling, swimming, volleyball, or dancing, for at least 10 minutes continuously? (USE SHOWCARDS)	YES ....1 NO……………………………………….2	➢skip 14 & 15
14	In a typical week, on how many days do you do moderate-intensity sports, fitness, or recreational (leisure) activities?	DAYS_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	

<table>
<tr><td>15</td><td>How much time do you spend doing moderate-intensity sports, fitness or recreational (leisure) activities on a typical day?</td><td>HOURS________MINUTES________</td><td></td></tr>
<tr><td colspan="4">Sedentary behaviour</td></tr>
<tr><td></td><td colspan="3">The following question is about sitting or reclining at work, at home, getting to and from places, or with friends, including time spent sitting at a desk, sitting with friends, travelling in a car, bus, train or taxi, reading, playing cards or watching television, but do not include time spent sleeping.

(USE SHOWCARDS)</td></tr>
<tr><td>16</td><td>How much time do you usually spend sitting or reclining on a typical day?</td><td>HOURS________MINUTES________
___ ________</td><td></td></tr>
</table>

<table>
<tr><td colspan="7">PHYSICAL ACTIVITY VARIABLES: minutes/week (min/wk.) for frequency

Met/minutes/week (met/min/wk) for intensity</td></tr>
<tr><td rowspan="2">Total Physical activity at work</td><td colspan="2">Vigorous</td><td colspan="2">Moderate</td><td rowspan="2">Total Moderate+Vigirous

(MVPA) min/wk

_________</td><td rowspan="2">Total MVPA

met/min/wk

__________</td></tr>
<tr><td>min/wk

______</td><td>min/wk*8= met/min/wk__
_____</td><td>min/wk

______</td><td>min/wk*4= met/min/wk__
_____</td></tr>
<tr><td rowspan="2">Total Physical activity at travel</td><td colspan="2" rowspan="2"></td><td colspan="2">Moderate</td><td rowspan="2">Total MVPA

min/wk

_________</td><td rowspan="2">Total MVPA

met/min/wk

________</td></tr>
<tr><td>min/wk

______</td><td>min/wk*4= met/min/wk
_______</td></tr>
<tr><td rowspan="2">Total Physical activity at leisure</td><td colspan="2">Vigorous</td><td colspan="2">Moderate</td><td rowspan="2">Total MVPA

min/wk

_________</td><td rowspan="2">Total MVPA

met/min/wk

________</td></tr>
<tr><td>Min/wk

______</td><td>min/wk*8= met/min/wk_
______</td><td>min/wk

______</td><td>min/wk*4= met/min/wk_
______</td></tr>
<tr><td>Total Sedentary behaviour</td><td colspan="2">Total min/wk_____

(calculated over 7 days)</td><td colspan="4"></td></tr>
</table>